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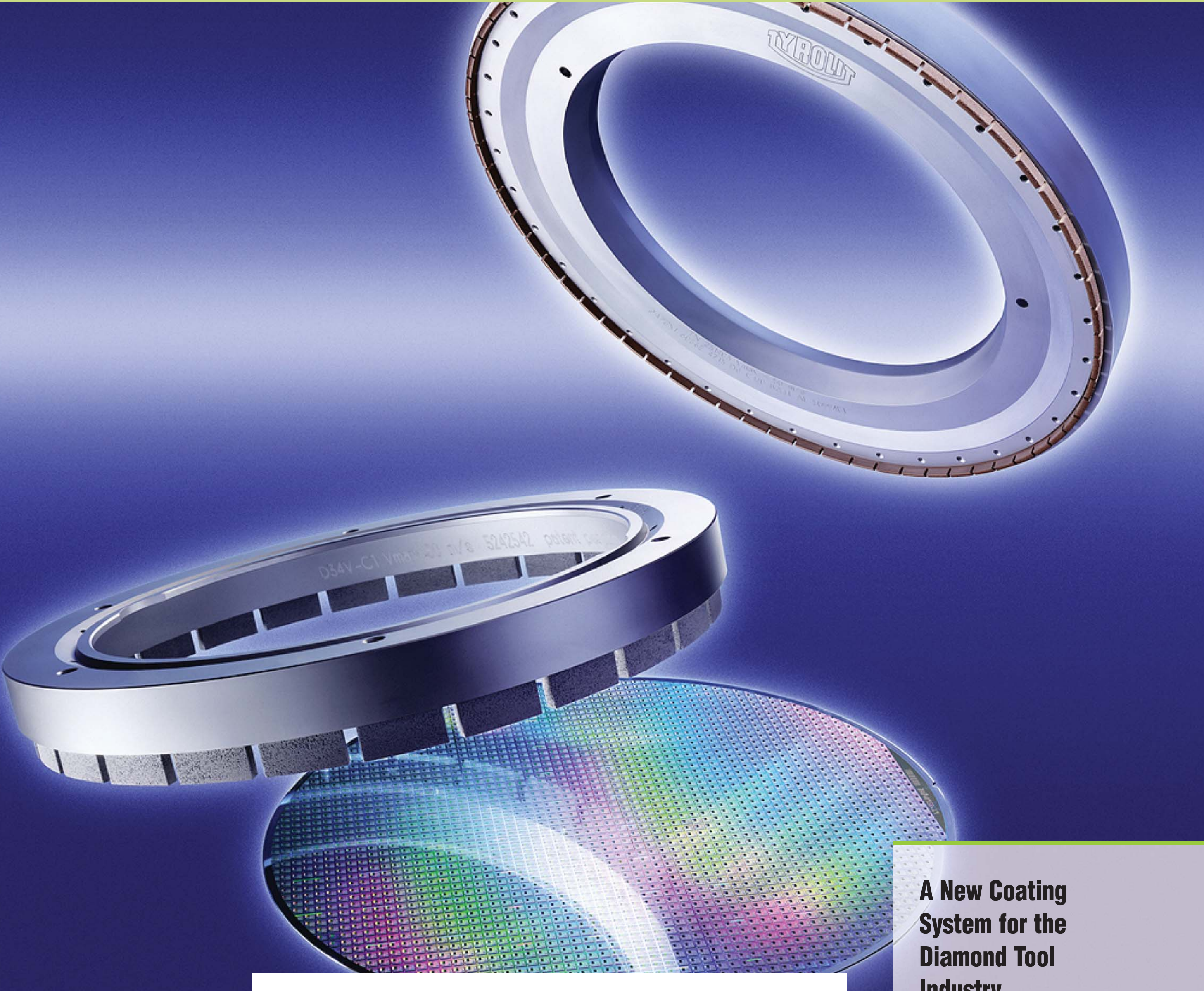

A New Coating System for the Diamond Tool Industry

INTERTECH 2006 Call For Papers

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Calendar of Events

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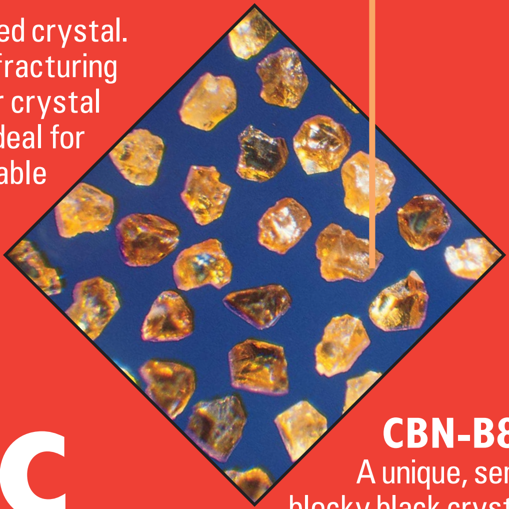

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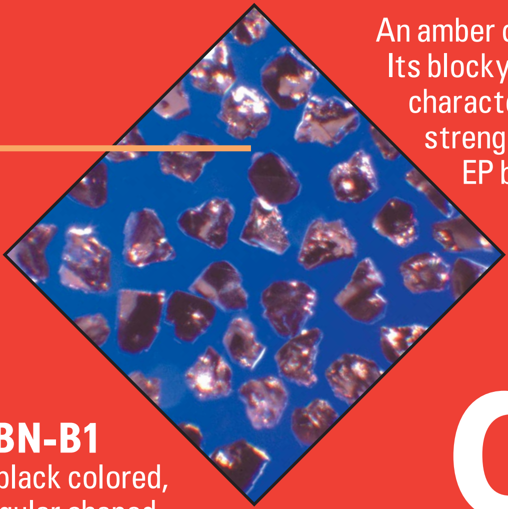

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COVER PHOTO

Photograph of diamond polishing courtesy of Tyrolit

FINER POINTS is the only publication devoted exclusively to the understanding, selection and application of diamond, cubic boron nitride and related materials. It is edited for recipients who are involved in some way with these "superabrasives", either as providers of the materials, producers of products containing the materials or users of these products (e.g., grinding wheels, dressing tools, drill bits, saw blades, sawing wires, cutting tools, polishing compounds, CVD film products, etc.).

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A Finer Point of View…

Driving home the other night a car pulled up on my left that looked like a beautiful restoration of an antique sedan. I noted the sleek but rounded fenders and lines of days gone by. Then it hit me that the shiny new emblem was not of a 50's automaker but the contemporary design of 2004… another great example that everything old becomes new again. It happens in our industry year after year. Someone gives a technical presentation on a new product design or application and some elderly scientist in the back of the room can be heard to mumble… "We did that back in 68"… my immediate thought is, did the guy mean 1968 or 1868! The truth of the matter is that things do get refurbished and renewed, but they usually get better in the process.

"Retro" has become a buzz word for stylish. The automotive industry has gone to great lengths to recapture the styles of yesterday. Of course the Chevy pickup/roadster with the rounded bumpers and 50's appearance commands 45-50,000 dollars depending on the addition of leather seats, a GPS system, wood dash, surround-sound audio, woofers, tweeters, amplifiers, digital displays and multi stack CD player… yeah, just what grandpa had out on the farm!

The auto industry is not alone. Fashion recreates itself constantly and beat styles of the 50's became hippy styles of the 60's and new age or new wave today… I keep getting those terms confused, but I know just as I started wearing pleated pants they went out of style and came back again… heaven help me the bell bottoms are in style (ok, they call them flare-legged) and hip huggers are back on all the teenage girls. Of course as a guy you'd think I would learn not to throw away old ties… narrow wide or whatever they'll be back! Even a hand me down polyester shirt can receive an admiring glance and a "nice retro" comment from the younger generation.

Music is always a long line of remakes, although at times I really have to search for the original melody and movies just keep rehashing the old themes… how many times can you remake the 1939 classic Love Affair? In 1957 it was An Affair to Remember and finally the 1994 Love Affair. There was also a made- for-TV movie with the same theme. At least the male lead changed from a French playboy in 1939 to an American playboy in 1957 to a former American Football star in 1994. That, in itself, is progress! Recently I read an article where economists are saying we need to rebuild the railroads. Apparently, travel and carrying freight across the highways is the least economic way of hauling freight or passengers. A shame we let them all decline… the rails had a certain class and now we may be trying to regain that nostalgia because it's profitable.

PRESIDENT
Joseph M. Haag

The diamond industry also rebuilds itself. Our board of directors has reviewed some of our current literature and even though the documents may seem dated, the pieces still are remarkably accurate. This is one reason we are starting to haul out the old publications and beginning to update and rewrite the information. In this way we can reinvest in the accumulated knowledge of our storied past.

Everyone gets nostalgic when reflecting on the way things used to be and that most probably comes from the fact there is always something of value we can glean from the past… So the IDA is learning from its own celebrated history and as we head towards our 60th year let the old become new again!

Sincerely,

Joseph Haag

Joseph M. Haag, President
Industrial Diamond Association of America

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Industrial Diamond Association
of America
P.O. Box 29460
Columbus, Ohio 43229
Phone: 614-797-2265
FAX: 614-797-2264

E-Mail:
tkane-ida@insight.rr.com

Website:
www.superabrasives.org

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APRIL 20-22, 2005

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WHERE:

- Aladdin Casino and Resort, Las Vegas, Nevada

WHEN:

- Wednesday April 20 through Friday April 22, 2005

WHAT:

- Major end users, economists, government agencies and our own members will interact with attendees to help improve business operations, increase profitability and share innovations and technological developments
- Discussions on Association projects and programs
- Planning of INTERTECH 2006 in Atlanta
- Organizing the 60th IDA Anniversary
- Network with members to share experiences and find solutions
- Enjoy the location… Aladdin Casino and Resort, Las Vegas, Nevada
- Great golf, sun, a little casino action and terrific sightseeing will compliment our strong business program. There will be plenty of time to interact and spend that quality one on one time at this unique venue.

WHY:

- The Annual Meeting is the one time and place you can get together with colleagues, customers, competitors, and friends to discuss issues and make plans to improve your individual business and grow our collective industry.
- Your voice is more important now than it has ever been!

PLANS BEING FINALIZED

- Look for updates and details on the IDA Website at: www.superabrasives.org

Who will you see in Las Vegas?

Plans are already underway for **INTERTECH 2006**, the Triennial Global Technical Conference on Diamond, Cubic Boron Nitride and their applications. Not only will this be our third conference built on the tremendous successes in 2000 and 2003, but it will also mark the 60th Anniversary of the Industrial Diamond Association! The Conference will be held at the Grand Hyatt Atlanta in prestigious and fashionable Buckhead. This most unique of hotels, voted one of the Top 50 Hotels in the USA is literally surrounded by the finest dining, shopping and nightlife, with convenient access to the Atlanta business community and downtown. We already have some great ideas to make this not only a rewarding technical experience, but also an enjoyable trip you will remember for quite a while! It's less than two years away, so clear your calendars for April 24, 25 & 26, 2006. If you are not yet an IDA Member, you'll want to join now to share in the 60th year celebration April 22 & 23, 2006! ***Watch for details!***

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Editorial

TERRY KANE, Editor

A Diamond Industry Loss

Whenever an industry icon passes away we are first struck by the void left behind and then we reflect on the measure of his life. This is the way I felt when I first heard John Van Itallie had died. I relayed the sad message to industry colleagues and as the word spread, replies came from all over the world reaffirming the way he touched so many lives. One close friend said "I miss him greatly and think of him often, I get a pang of sorrow… but at the same time I have a joy just thinking of him". That was the feeling expressed by the many calls and emails, each carried simple notes of sadness as well as personal glimpses into the humor and class that was John Van Itallie.

In the years I have been associated with the diamond industry I have constantly come across John's name and the name Van Itallie in the literature and documents of the IDA. I still keep a copy of the book co-written by John called *The Industrial Diamond* as a reference for various discussions on diamonds. In fact, this book has been identified by many as a lynch pin of industrial diamond reference materials. The book was first published in 1964 and the second edition, which was completed in 1979, took a full two years in development. To this day, it is still informative and relevant. John was such a dedicated expert that he not only oversaw the production of the book, but also wrote two chapters, one on *Natural Diamond Sources And Production* and another on *Manufactured Diamonds*.

John's life could only be labeled as diverse. He served for several years on a U.S. Navy destroyer escort, attended Princeton University and started in the diamond industry with a career of purchasing, sorting and selling industrial diamonds. He worked for both of the largest diamond companies in the industry dealing in both natural diamonds in the 40's and then as a pioneer distributor of the fledgling manufactured diamond product in the 50's. John was awarded an IDA Honorary Lifetime Membership as recognition of his years of service and leadership in this industry.

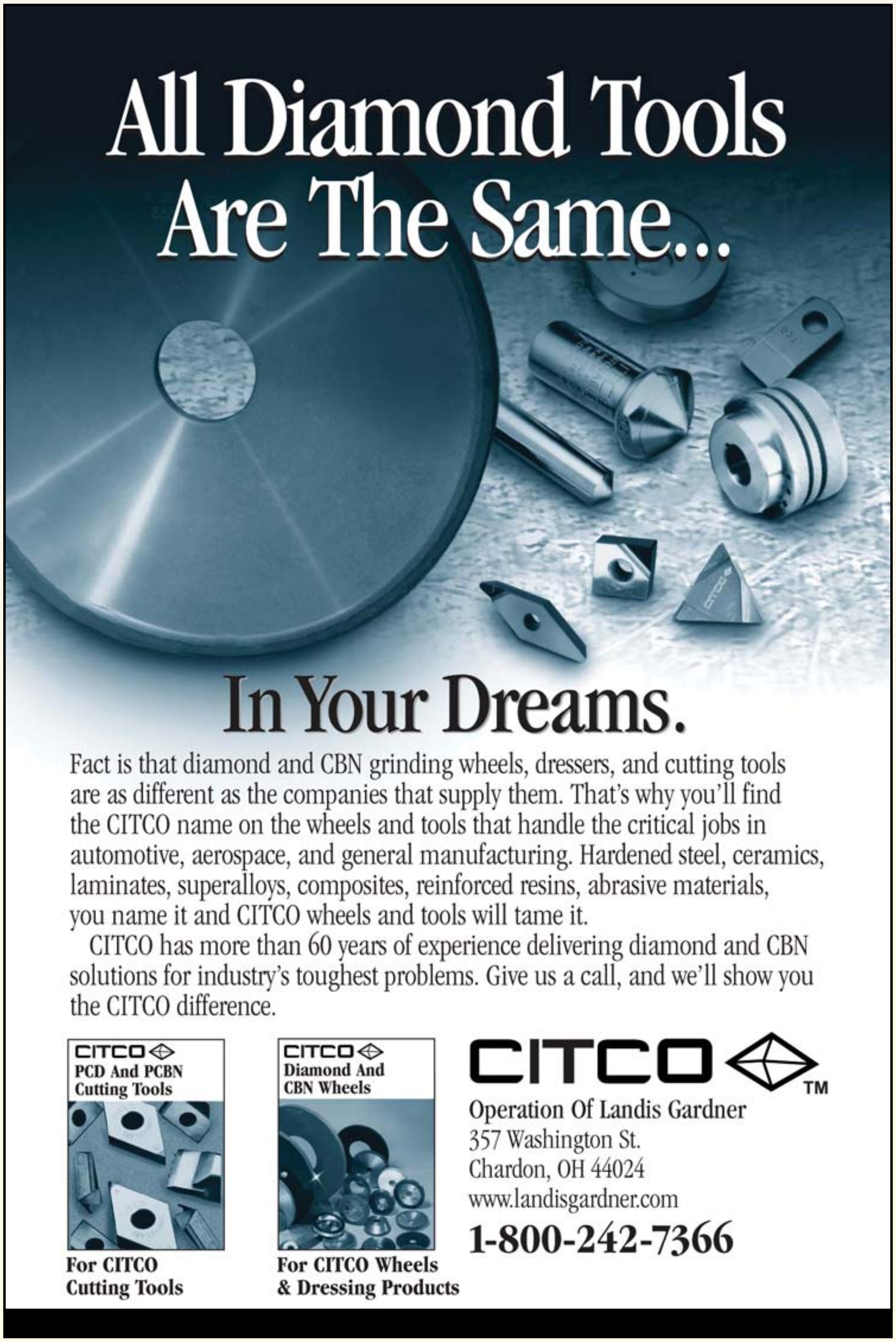
Outside the diamond business, John owned a shrimp boat and a newspaper where he wrote a weekly column. He also took over a winery that had been in his late wife's family for 300 years… and as was John's way, he read books and every year went back to Germany and worked in the vineyards, picking grapes and learning more and more about the winemaking business. His winning personality carried over to his game of golf and his friends noted he was an avid and competitive golfer.

After he retired from the diamond business John became fascinated with Indian art, so he founded and was principal owner of The Lovena Ohl Art Gallery in Scottsdale, Arizona. Diversity was definitely a term well applied to John D. Van Itallie.

I first met John when he was President of the Van Itallie Company and kept in contact only through infrequent emails… his last was just a change of address and a short compliment of the IDA and how he still enjoyed reading the Finer Points.

I was well aware of John's standing among his peers and how all who were acquainted with him in this industry respected him. Legends grow and stories get embellished about a man like John. One of his many friends told me the other day, "John was clever and wise" … Maybe that is the best way to remember the man.

John D. Van Itallie
1927- 2004



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A New Coating System for the Diamond Tool Industry

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Silicon Carbide Coating On Diamond Found Superior

The characteristics and applications of a novel silicon carbide coating on diamond has been found to provide superior protection from chemical attack without compromising diamond retention in the tool. This enables the toolmaker to realize significant cost savings with less expensive, chemically more aggressive bond materials. Silicon carbide-coated diamond has been found to be well suited for tools processed at high-temperatures as well. This coating will be compared to other coatings commonly used in metal-bonded diamond tools. Experimental data show that tools made with silicon carbide-coated diamond provide improved performance and life in different applications. Finally, this study also defines the operating regime in which this new coating provides the maximum benefit to the toolmaker.

Strategies For Improving Tool Performance

Synthetic diamond is an abrasive commonly used in stone, concrete and asphalt applications involving circular saws, thinwalled core-drills, impregnated exploratory mining bits, gang saws and wire saws. The parameters used most often for characterizing tool performance are free-cutting ability, or the power required, and tool

Diamond Saw Cutting Reinforced Concrete

life. Wear mode analysis of the tools is used to determine the fraction of whole and crushed diamonds and the number of diamond pop-out sites (***Photo 1***).

This data is analyzed to identify the appropriate bond and diamond characteristics (mesh size, grade and concentration) and, hence, the strategies for improving tool performance. Coated diamonds, introduced in the last decade, were intended to aid in crystal retention and enhancement of tool life. Recent results indicate the benefits of titanium carbide and chromium carbide coatings on tool life. Increasingly, the cost of typical metal bond powders like cobalt has forced a search for alternative bond materials. Iron has been recognized as a low-cost alternative; however, the negative effects of iron on diamond strength have inhibited a more comprehensive adoption of iron by toolmakers. Existing titanium- and chromium-based coatings were inadequate to the task of protecting the diamond in iron-rich bonds. In answer to this challenge, a new silicon carbide coating was developed. The objective was to provide the conventional benefits of improved crystal retention while enabling application in aggressive metal bonds that might be processed at high temperatures. In this paper, the characteristics of the silicon carbide coating, its applications, and experimental examples of its superior performance are discussed. Finally, the cost advantages enabled by the use of silicon carbide coated diamond in iron-rich bonds are highlighted.

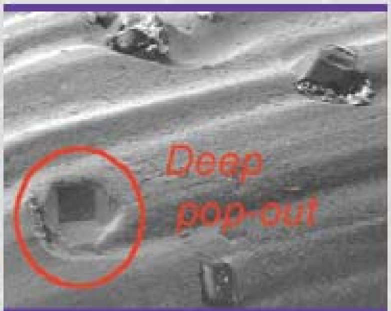

PHOTO 1
Uncoated Crystal Popout

PHOTO 2
Titanium-based coated diamond

Characteristics Of Silicon Carbide Coatings

Silicon carbide coatings can be applied at relatively low temperatures. Therefore, any process-associated diamond degradation is minimized; further, the coating can be applied irrespective of the thermal stability of the diamond. The benign nature of the process enables the application of the coating on the entire range of diamond grades–weaker, friable diamonds to the cubo-octahedral, tough diamonds–with little effect on the toughness index (TI) value of the underlying crystal. The temperature at which the silicon carbide coating oxidizes has been measured, by thermal gravimetric analysis, to be 980°C. By comparison, titanium-based coatings (***Photo 2***) oxidize at 780°C.

This difference in coating breakdown temperature provides greater flexibility in tool fabrication without any loss in coating properties. It can also eliminate the need for atmosphere control during sintering, a potential cost savings to the tool fabricator. Typically, diamond, which is a meta-stable form of carbon at normal conditions, is known to oxidize or convert to the more stable form of graphite at elevated temperatures in the presence of catalyzing elements like iron and in oxygen-rich environments. Further, at elevated temperatures, the metallic inclusions commonly found in synthetic diamonds expand and contribute to the reduction of diamond strength. The protection offered by a silicon carbide coating (SiC-coating) compared to a baseline uncoated crystal was explored. Several segments, made with SiC-coated and uncoated diamond, were sintered at 900°C for 4 minutes in a bond made of 100% iron. Scanning electron micrographs in ***Photo 3*** show a comparison of the uncoated and SiC-coated diamonds. ***Photo 3(a)*** shows the uncoated diamond to be visibly damaged by the iron-temperature combination. However, the SiC-coated diamond is not degraded ***Photo 3(b)***. The crystal facets are smooth and the edges are sharp. The SiC-coating was observed to provide a remarkable degree of protection to the crystal.

Some of the crystals were recovered by dissolving the bond. Further, the SiC-coated crystals were stripped of the coating. Optical micrographs are shown in ***Photo 4***. The recovered uncoated diamond in ***Photo 4(a)*** shows visibly etched diamond and regions of surface graphitization. The SiC-coated diamond in ***Photo 4(b)***, on the other hand, is essentially unaffected.

The SiC-coating has helped the underlying diamond withstand the deleterious effects of iron. A comparison was also carried out between uncoated and SiC-coated diamond on the effects of high sintering temperature without the presence of catalyzing elements. It was found that the silicon carbide coating provided remarkable protection to the crystals at temperatures as high as 1100°C. Furthermore, the silicon carbide coating was experimentally observed, using electron dispersive x-ray spectroscopy, to be favorably wetted upon hot pressing by iron, copper, cobalt, nickel, and manganese, among other common bond constituents. X-ray maps showing the wetting of SiC-coated crystals by iron, cobalt, nickel and copper are shown in ***Photo 5***.

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Experiments In Iron-Rich Bonds

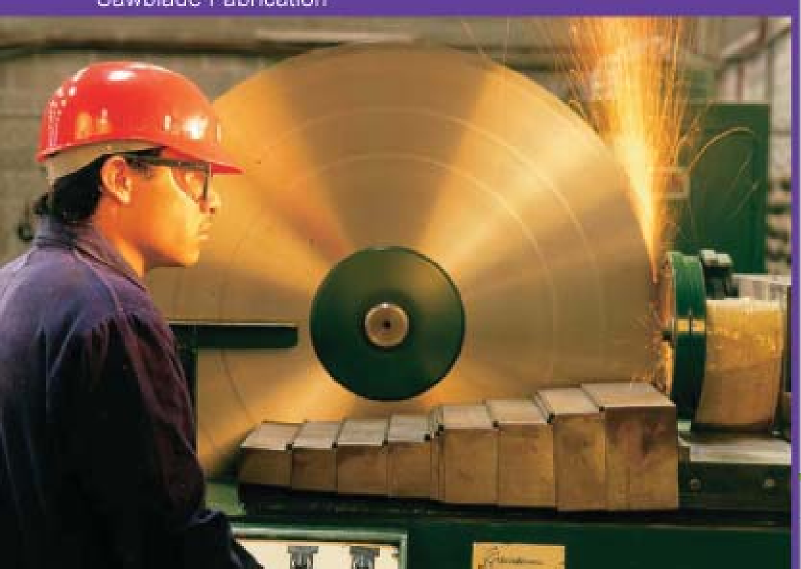
Two sets of material removal experiments, in concrete and quartz, were carried out to evaluate the effectiveness of silicon carbide coated diamond in iron-rich bonds. One of the major metrics of interest was the performance of the SiC-coated diamond in an iron-rich bond.

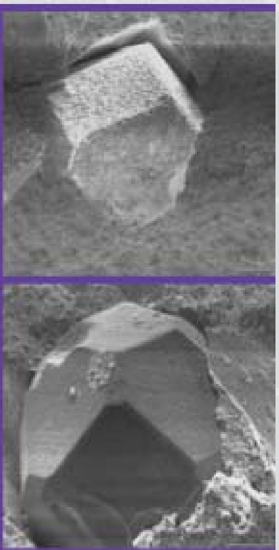
Concrete Sawing Evaluation

Blades made with SiC-coated diamond in a special iron-based bond were compared with those made with the standard diamond being used in flat sawing of steel-reinforced (re-bar) concrete. The objective of the test was to determine the free-cutting ability and wear performance characteristics of the SiC-coating in such a high-iron bond. Fracture surface analysis of the segments showed impressive coating-bond compatibility (see ***Photo 5*** for instance). Generally, such an interaction is an indicator of improved crystal retention. Reclaimed SiC-coated diamond showed little or no visible degradation. 26-inch diameter blades with 46 segments that were approximately 0.2-inch tall were used. Initially, the grade of the SiC-coated diamond was kept the same as the standard product. A custom-built walk-behind saw with a 90-hp Vortec engine was used in the testing (***Photos 6 & 7***). A depth of cut of 9 inches was used.

The operator reported that the free-cutting ability of the blade with SiC-coated diamond was marginally better than that of the standard blade. However, in terms of the total number of feet sawn, the SiC blade displayed a 14% improvement in life over the standard blade. A comparison of the wear modes of the used blades from this test is shown in ***Figure 1***. The blade had a higher percentage of whole crystals and most of these whole crystals showed indications of being polished. This polishing action, in turn, could have contributed to

Sawblade Fabrication

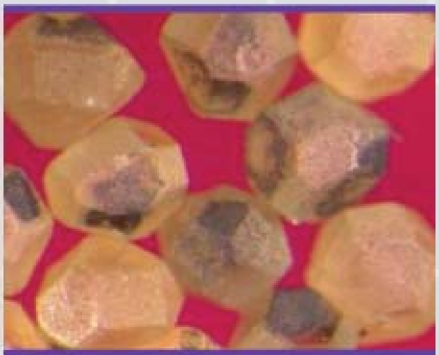




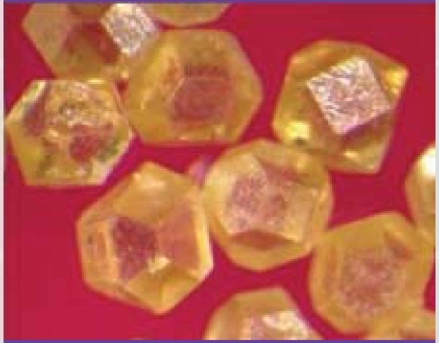
(a) Uncoated

(b) Silicon carbide coated

PHOTO 3
Fracture surface images of diamonds in 100% iron bond, sintered at 900 °C for 5 minutes at peak temperature (a) Uncoated (b) Silicon carbide (SiC) coated diamond. The uncoated diamond is damaged on the surface while the silicon carbide coated diamond is unaffected by the temperature and the bond. See also Photo 4.



(a) Uncoated



(b) Silicon carbide coated

PHOTO 4
Diamond reclaimed from 100% iron bond, sintered at 900 °C for 5 minutes at peak temperature (a) Uncoated (b) silicon carbide (SiC) coated diamond. The uncoated diamond shows signs of graphitization while the silicon carbide coated diamond is visibly undamaged.

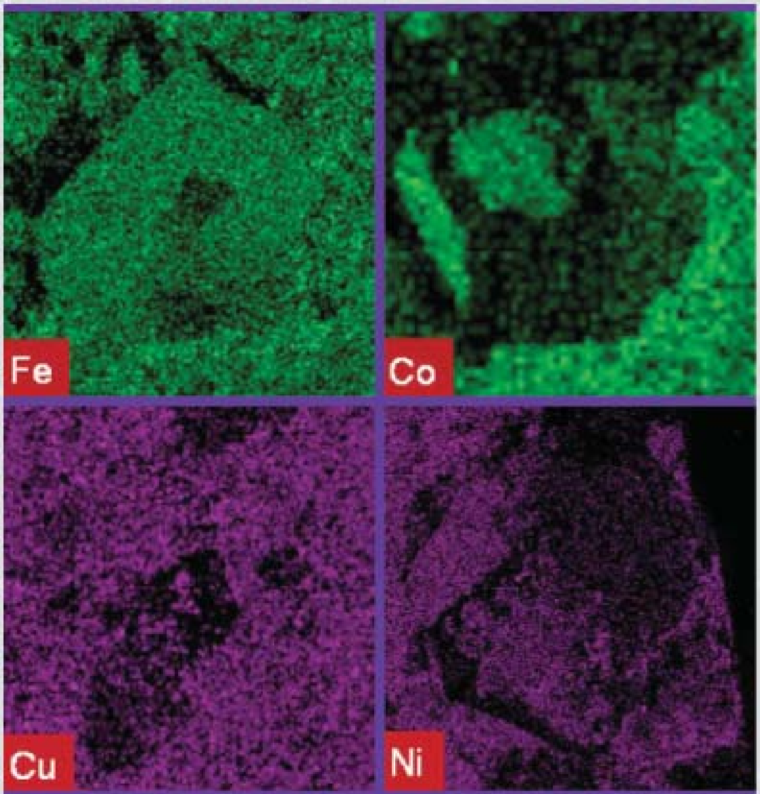


PHOTO 5
X-ray maps identifying bond components wetting the SiC-coated crystals. Iron, cobalt, copper and nickel react well with the SiC-coating at typical metal-bond sintering temperatures. The SiC-coated crystal silhouette and the bonds are clearly seen.

PHOTO 6 – Cutting Rebar Concrete

PHOTO 7 – Diamond Blades

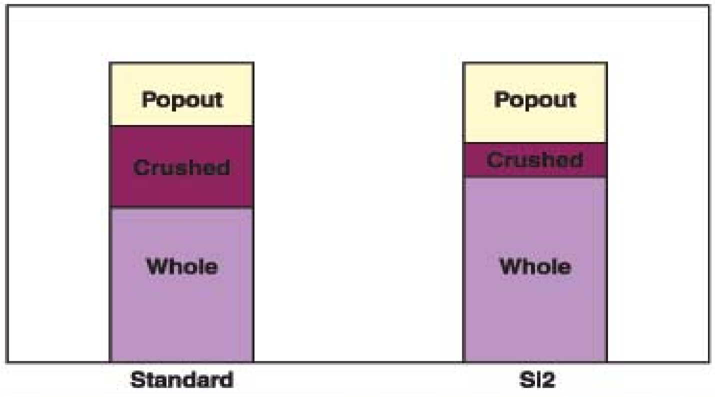


Figure 1 – Analysis of used blades from reinforced concrete (Test I). The higher number of whole crystals in the SiC blade had a large fraction of polished crystals. The polishing effect also contributed to the higher popout percentage in SiC diamond.

the higher popout percentage in the SiC blade. The polishing effect is attributable to the diamond grade being higher than required for the application. Therefore, in the second round of testing a blended product was used in an identical bond.

The saw operator reported the SiC blade to be significantly freer cutting than the standard blade. Furthermore, the alteration in the crystal blend resulted in the SiC blade delivering a 24% improvement in life. The relative blade life from the two tests is shown graphically in ***Figure 2***. The improved free-cutting ability of the second blade was attributable to the blended product. However, the protective qualities of the SiC-coating against iron were responsible for the enhanced tool life in an iron-rich bond. Further, in addition to lowering bond cost, the usage of this coating enabled a switch to a lower grade diamond blend.

Quartz Core-Drilling Evaluation

Quartz, while hard to cut, is not abrasive. Hence, the diamond in a core bit (***Photo 8***) does not usually break down rapidly. This can often lead to diamond polishing in the tool, resulting in higher power requirement with time. As the free-cutting ability of the bit decreases, the power increase tends to strain the capacity of the motor. Poorly executed core-drilling operations can result in a variety of undesirable surface features that reduce the value of the core. Typically, the operator retracts the bit to ease on the power being drawn and re-inserts it. Such an operation can wear out the clutches on the coredrills. The challenges for the toolmaker is to fabricate a tool with wear characteristics that will enable aggressive removal rates. Two sets of core-drilling experiments were conducted.

The objective was to improve the free-cutting ability of the bits while lowering the tool cost. An experimental core drill, 11 inches in diameter, was tipped with 16 segments 1-inch long and 0.125-inch thick. The segments were fabricated with SiC-coated diamond in a special iron-rich metal bond. These were compared against standard bits containing uncoated diamond. The drilling power drawn was recorded on a computer, using an analog-to-digital converter, for further analyses. A comparison of the specific energy (power consumed per unit volume of material removed) is shown in ***Figure 6***. The experiments demonstrated that the standard (uncoated) bit required repeated operator intervention (note the

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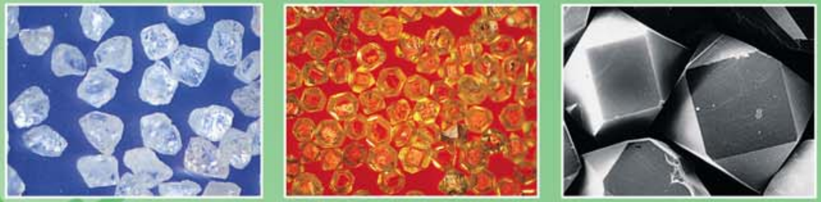

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- Parts Manufacturing
  - Gears
  - Wheels
  - Transmissions
  - Engines
  - Other
  - Materials
    - Metal Matrix Composites
    - Bi-Metals
    - High Tech Ceramics
    - Glass

Other Manufacturing
- Pumps
- Motors
- Heavy Equipment
- Etc.

Electronics
- Disc Texturing
- Wafer Mfg.
- Polishing
- Optic Windows
- Semiconductors

Emerging Technology
- CVD
- New Crystals
- Coatings
- Other

Machine Tools
- Development
- Innovations
- Advancements
- Superabrasive Adaption

Medical
- Surgical Knives
- Prosthesis Fabrication

Construction/Highway
- Concrete
  - Aggregates
  - Variables
- Highway/Runway Grinding & Grooving
- Bridge repair
- Renovation
- Block Grinding, Polishing, Application

Stone Processing
- Quarrying
- Sawing
- Polishing
- Materials

Mining/Drilling/Natural Resource Exploration

Optics
- Polishing
- Lens Generation
- Polishing

Wire Drawing
- New Technology
- Applications

Woodworking
- Hard Woods
- Fiberboard
- Laminates
- Composites
- Film (CVD & PVD)
- Magnetorheological
- Finishing
- ELID etc.

Suppliers to Superabrasive Industry
- Metals
- Coolants
- Measuring & Gauging
- Safety
- Other

Research and Development
- New Crystals/Abrasives
- New Coatings
- Bond Development
- Testing/Gauging
- Tool Fabrication
- Materials
- Tooling
- Application

INTERTECH 2006! It's coming! The triennial INTERTECH promises to be the most comprehensive commercial and technical conference ever held for industrial diamond, cubic boron nitride, polycrystallines, CVD and other related superabrasives! Leading experts from industry will be there, presenting papers on subjects that will improve performance, increase productivity and reduce manufacturing costs. This will be an international "meeting of the minds" on new technology and applications for grinding, machining, turning, sawing, wire drawing, polishing and literally every other aspect of manufacturing or services. This spectacular event will be held from April 24 through April 25, 2006 in the beautiful old southern city of Atlanta Georgia, USA. INTERTECH 2006 will be co-sponsored by the leading global Organizations for this industry - Abrasive Engineering Society, ASM International, Assodiamante, Concrete Cutting Industry Association of Australia, Concrete Sawing & Drilling Association, F.E.P.A., IDA-Americas, IDA-China, IDAIndia, IDA-Japan, Japan Society for Abrasive Technology, Society of Manufacturing Engineers (SME) and the Unified Abrasive Manufacturers Association (UAMA). You can be part of this exciting event! We are now soliciting commercial and technical papers of approximately 30 minutes length that address the development of these super-hard materials as well as the dynamics and application of superabrasive systems, with a focus on new technology, cutting tools, grinding wheels, machines, wire drawing, innovation, etc., related to PRODUCTIVITY and PERFORMANCE.

If you wish to present a paper, send a one or two paragraph abstract of your topic ***with a copy of this page*** via E-Mail, FAX or mail to:

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INDUSTRIAL DIAMOND ASSOCIATION
P.O. Box 29460
Columbus, Ohio 43229
PH: 614-797-2265   FX: 614-797-2264
E-Mail: TKane-IDA@insight.rr.com

Abstracts are now being accepted, contact us today to be considered. We will respond to all submissions.

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I propose to present the paper described in the attached abstract at INTERTECH 2006 ... *(Please Print Clearly and Include Abstract)*

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periodic fluctuation in the specific energy measure) to alleviate the power build-up. Drilling power increased until the operator intervened to briefly retract the drill. The SiC core-bit, on the other hand, needed no corrective measure during a comparable 11-inch cut. The power measurement for the SiC bit was relatively constant through the entire cut. Data in ***Figure 3*** show that the specific energy associated with SiC bit is about half that required with the standard bit. This directly translates to a two-fold increase in core-drilling productivity with SiC-coated diamond in an iron-bond tool.

Comparison With Other Coated Diamond

Several other coated diamond products are commercially available including those that are titanium (Ti) and chromium (Cr) based. A test matrix (***Table 1***) comprising iron and cobalt bonds and their combinations was constructed to study the protection provided by each of the coatings. A protection index map was generated for uncoated diamond and compared with those of the coated diamonds (***Table 1***). The protection characteristics were visually evaluated on a bond-temperature space and ranked based on the diamond integrity. The bond was varied discretely from 100% cobalt to 100% iron with two intermediate iron-cobalt combinations. Tool blanks were sintered at three temperature levels, 700°C, 900°C, and 1100°C. A regression analysis on the resulting data provided a transfer function between the protection index and the bond-temperature variables.

Evaluation of the crystal condition of the sintered uncoated, Ti- and SiC-coated diamond enabled a determination of the preferred operating regime in the bond-temperature space (***Figure 4***). The uncoated diamond is most likely to suffer diamond damage with increasing temperature and/or iron percentage.

Titanium (Ti) coatings are found to be useful at moderately high temperature and iron fractions. The protection offered by SiC-coatings is significantly more than that offered by Ti-coatings, especially at high processing temperatures and percentages of iron (also see ***Photos 2 & 3***) and combinations thereof. Titanium coated diamonds have found wide acceptance because of their contribution to improved crystal retention. However, SiC-coated diamond can deliver the same retention benefits over a wider range of bond materials and processing conditions.

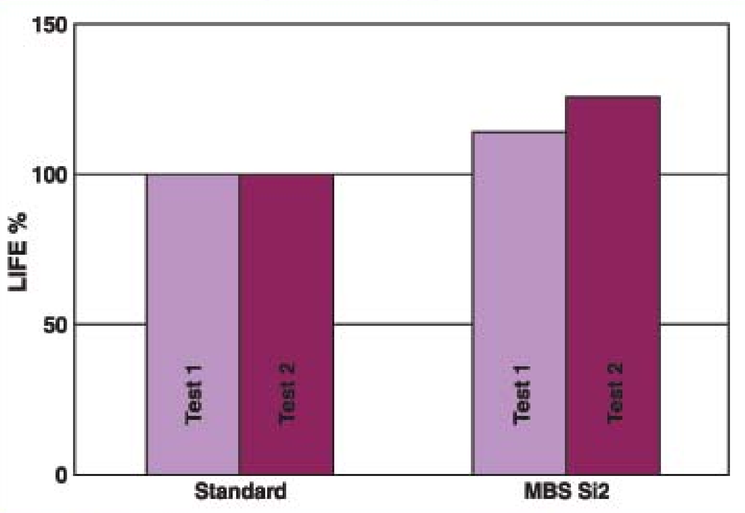


Figure 2 – Concrete sawing footage comparison. The SiC blade in an iron-rich bond consistently sawed more than the standard blade. In the second test, the blended SiC diamond grade was also found to be freer cutting than the standard blade.

Photo 8 – Core Drilling Application

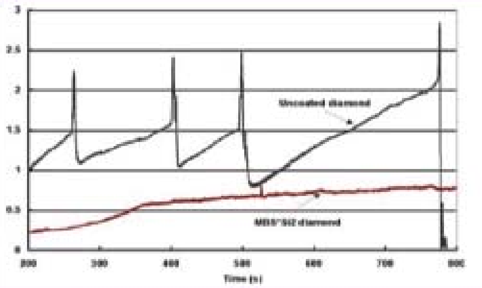


Figure 3 – Quartz core drilling. Specific energy (power per unit volume removed) of the core-bit containing SiC-coated diamond was, on average, two-times lower than with uncoated diamond. The lower power requirement with SiC-coated diamond translates into faster cutting and improved productivity.

TABLE 1: Test Matrix to Evaluate Diamond Integrity

VARIABLE	SETTING
Bond Composition	1.0 Fe – 0.0 Co
	0.7 Fe – 0.3 Co
	0.3 Fe – 0.7 Co
	0.0 Fe – 1.0 Co
Sintering Temperature	700°C
	900°C
	1100°C
	Uncoated
	Titanium-Based (Ti) Coated
Diamond Type	Chromium-Based (Cr) Coated
	Silicon Carbide (SiC) Coated

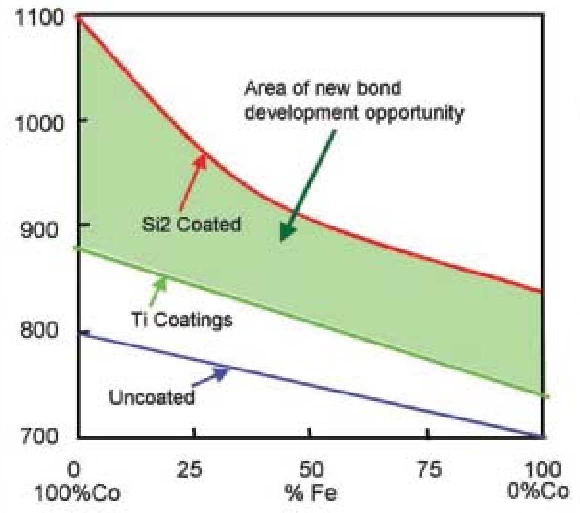


Figure 4 - Schematic showing operating regimes for uncoated, Ti-coated and SiC-coated diamond on the bond-temperature space, based upon diamond integrity after sintering. The x-axis shows the percentage of iron in the bond. The balance material in the bond is cobalt.than the standard blade.

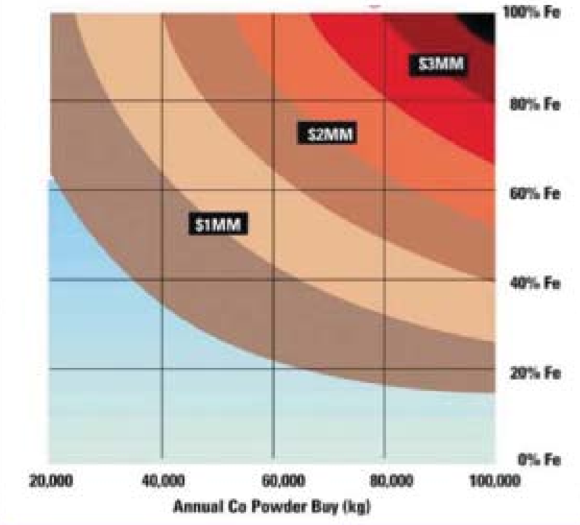


Figure 5 - Projected cost savings by substituting cobalt with iron. For instance, a toolmaker currently buying 60,000 kg of cobalt (at $50/kg) per year can save almost $1 million in direct materials cost by replacing 40% of the cobalt with iron, facilitated by the use of SiC-coated diamond.

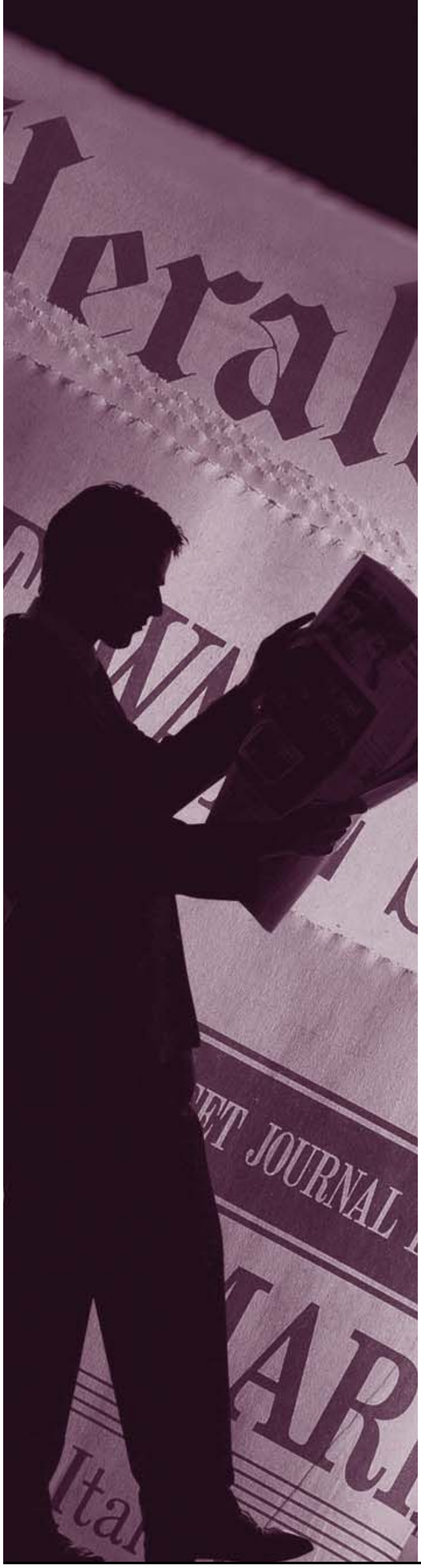
Toolmaker Cost Savings

The remarkable protection to the crystal that the SiC-coating affords opens up a window of bond development that would enable the toolmaker to realize significant cost savings. To explore this aspect, a cost model was developed to account for the weight of the crystal, the bond constituents and their respective costs. The model relies on the volume of a metal-bond segment and the densities of the bonds assuming a complete densification of the segment. Traditionally, 100% cobalt has been the metal powder composition of choice for metal-bond toolmakers, particularly for tools in the stone and construction markets. However, there is approximately a five-fold difference in the powder metal prices of cobalt and carbonyl iron. Internal studies have shown that it is feasible to substitute as much as 70% of the cobalt with iron to produce segments with the appropriate hardness. Further, such a replacement would also enable a toolmaker to reduce costs associated with the environmental aspects of handling conventional micron-sized cobalt powder. ***Figure 5*** shows a chart of the projected cost-savings a toolmaker can expect to realize depending on the volume of cobalt currently being utilized. The x-axis shows the cobalt powder (in kilograms) being used by a toolmaker and the y-axis shows the fraction of cobalt that can be replaced with iron. For instance, a toolmaker buying 40,000 kg of cobalt at $50 per kilogram per year can replace 40% of the cobalt with iron and expect a direct materials cost saving of almost US$1 million.

Coating Provides Significant Cost Savings While Improving Tool Performance

A new silicon-based (SiC) coating has been developed and tested. In addition to enhancing crystal retention, it has been found that the SiC-coating provides protection against diamond damage induced by iron rich bonds or high processing temperatures (as in impregnated mining bit processing) or both. SiC-coated diamond was preferentially wetted by common metal bond components, such as iron, cobalt, copper, nickel, and manganese, indicating improved crystal retention. The SiC-coating also demonstrates superior diamond protection compared to Ti-coated diamond at elevated temperatures. Experimental data from two applications cited in this paper show that SiC-coated diamond in an iron-rich bond significantly outperforms existing standard tools. The relative inertness of the SiC-coating against iron provides a large window of opportunity for toolmakers to explore new bond materials and processing conditions while retaining diamond integrity. It is feasible to replace up to 70% of cobalt by weight with iron while retaining the hardness of the segment. The introduction of a large fraction of iron into metal bonds should enable the toolmaker to realize significant cost savings without compromising on tool performance. ■

NEWS and notes



SUMITOMO ELECTRIC

WESTERVILLE OHIO… THE SUMITOMO ELECTRIC CARBIDE COMPANY, DIAMOND DIVISION ANNOUNCED THE APPOINTMENT OF DAVID SIMPSON AS SUMITOMO ELECTRIC-DIAMOND GROUP SALES MANAGER.

Dave graduated from Michigan State in 1989 with a degree in Business and has been with Sumitomo since 1998. Mr. Simpson's major responsibilities are Sales and marketing for the America's. He presently serves as a Director for the Industrial Diamond Association and is Chairman of the IDA Membership committee. Dave also is on the board of directors for the Wire Association International Ohio Valley Chapter.

SP3 DIAMOND TECHNOLOGIES

SP3 INCORPORATED, MT. VIEW CALIFORNIA AND SEKI TECHNOTRON, TOKYO, JAPAN ANNOUNCED A WORLDWIDE EXCLUSIVE DISTRIBUTION AGREEMENT FOR SP3'S MODEL 600 HOT FILAMENT DIAMOND DEPOSITION SYSTEM.

Makoto Seki, President of Seki stated that the addition of the SP3 Hot Filament system to Seki' s diamond equipment offerings will provide an important scaling path for the established base of over 250 users of Seki' s microwave diamond deposition systems. The SP3 system has a deposition area of 300 mm by 350 mm and has the capability of coating several hundred cutting tools at one time or silicon wafers up to 300 mm. Combining Seki' s world wide marketing and service organization with SP3's many years of building and running production scale diamond reactors will be a tremendous benefit to users of this important technology world wide. For information contact: James Herlinger President SP3 Inc. Phone (650) 966-0630 Email: jherlinger@sn3inc.com Fax (650) 966-0633

KNORR-BREMSE

MUNICH, GERMANY, BENDIX COMMERCIAL VEHICLE SYSTEMS FORMS NORTH AMERICAN JOINT VENTURE WITH DANA CORPORATION

DANA

Bendix Commercial Vehicle Systems LLC, Elyria, Ohio, the North American subsidiary of Knorr-Bremse AG, Munich, has signed a definitive agreement with Dana Corporation to create a North American joint venture focused on commercial vehicle foundation brake components and technologies The joint venture transaction will operate under the name Bendix Spicer Foundation Brake LLC. Dana Corporation is a global leader in the design, engineering, and manufacturing of value-added products and systems for automotive, commercial, and off-highway vehicles. Dana operates technology, manufacturing, and customer-service facilities in 30 countries. Sales from continuing operations totaled $79 billion in 2003 Additional information on the company is available on the Internet at www.dana.com. For further information, please contact: Knorr-Bremse AG Tel: +4989-3547-1402, Fax: +49 89-3547-1403 E-mail: eva.seifert@knorr-bremse.com.

BOURN & KOCH

BOURN & KOCH INC. LOCATED IN ROCKFORD, IL WAS APPROVED BY THE U.S. BANKRUPTCY COURT AS THE SUCCESSFUL BIDDER FOR THE ASSETS OF DEVLIEG BULLARD II MACHINE TOOL AND SERVICES DIVISION.

The purchase includes the product lines of Bullard, DeVlieg, Motch, Springfield, White Sundstrand, Rockford Machine Tool, Futurmill, Mattison Grinders, Blanchard, Brown & Sharpe, American Tool, Acme-Gridley, Conomatic and New Britain Machine. For further information contact Timothy Helle, President Bourn & Koch (815) 965-4013, Fax: (815) 965-0019 www.bourn-koch.com

mti manufacturing technology inc.

MANUFACTURING TECHNOLOGY INC. (MTI) LAUNCHES NEW WEBSITE

www.mtionline.com Ventura, CA -- Manufacturing Technology Inc., (MTI), is pleased to announce the launch of their newly created and greatly anticipated website, designed to communicate, enlighten, and instruct potential customers. MTI, is known worldwide as a leading-edge manufacturing company that designs and manufactures high performance, ultra precise machine systems for slicing, dicing, singulating, grinding, slotting, and lapping applications. Additionally, the company offers a full range of contract manufacturing services and premium cutting tools, (diamond/CBN blades and carbide saws) and accessories.

LACH DIAMOND INC. INTRODUCES THE NEW AND UNIQUE “MINI” UNIVERSAL GRINDER FOR ALL TYPES OF DIAMOND WOODWORKING TOOLS.

The so-called “mini” (model name Dia-2100-mini) is the ideal grinder for shops that would like to start diamond grinding and sharpening and would like to take advantage of the long diamond experience of the Pioneer LACH. The “mini” is recommended for all diamond tool manufacturers looking for an alternative to extend their diamond resharpening service in-house or outside regions. **For information contact: Lach Diamond Inc1-800-LACH-USA, Fax: (616) 698-0232 or Email: office@lach-diamond.com**

COMMERCIAL-GRADE FULLERENES PRODUCTION QUANTITIES INTRODUCED by Nano-C, LLC

Westwood, Massachusetts – Nano-C Fullerenes are exotic carbon molecules with distinct chemical, electrical, and optical properties that enhance the performance of a wide range of products used in many different industries. Applications for Nano-C Fullerenes include polymer photoelectronics where they are used as electron acceptors in plastic solar cells and photo-detectors; non-linear optics; drugs and biomedical devices and various types of coatings and films. **For more information contact: David Kronholm, PhD, (781) 407-9417 e-mail: info@nano-c.com www.nano-c.com**

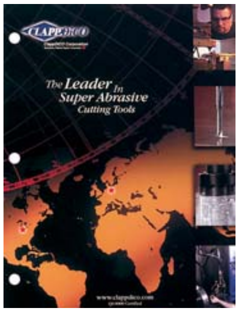
Tri-Mer® Corporation

1400 Monroe St. • P.O. Box 730 • Owosso, MI 48867 • (989) 723-7838 • Fax (989) 723-7844

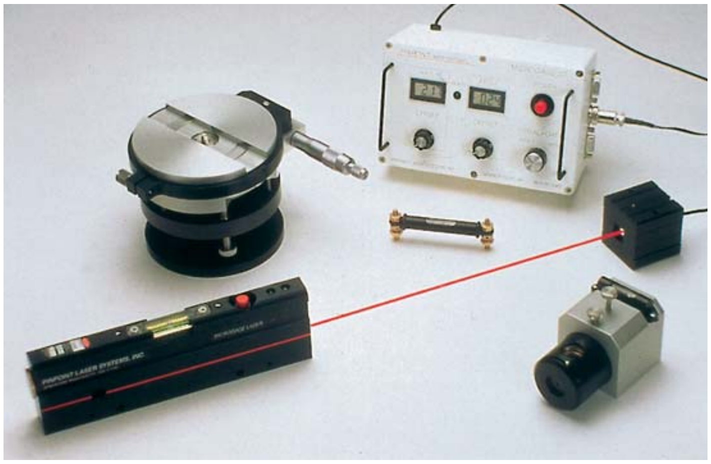
EXOTIC METAL FINES COLLECTOR ELIMINATES EXPLOSION HAZARD. ENHANCES SAFETY

Owosso, Michigan – Tri-Mer Corporation, a manufacturer of dust and particulate collection systems for industry, has introduced a system for the safe, and highly efficient collection of fines and dusts from the processing of exotic metals. Trade-named Whirl-X™, the system is engineered for the collection of fines from grinding, sanding and deburring operations involving aluminum, magnesium, titanium, beryllium, uranium and other exotic metals. Whirl-X captures 99.9% of all dusts five microns and larger. Systems can also be engineered to return air to the plant in some instances, reducing HV AC costs. Systems are manufactured in capacities from 425 cfm to 50,000 cfm. **For more information: Tri-Mer Corp. 1400 Monroe St., Owosso, MI 48867. 989-723-7838. www.tri-mer.com**

NEW FULL LINE CATALOG FROM CLAPPDICO CORPORATION



Whitehouse, Ohio – ClappDiCO Corporation, a leader in the manufacture of Super Abrasive Precision Tools, introduces its new full line product catalog. The catalog offers a comprehensive look at the entire line of superabrasive cutting tools available from the company. The new catalog includes a Milling Blade Identification Chart detailing ordering nomenclature and comprehensive instructions for Mill Cutter Set-Up procedures. **For a copy of the new catalog or for more information, contact ClappDiCO Corporation 1.800.537.6445 or email sales@clappdico.com**



2-AXIS LASER ALIGNMENT TOOL IMPROVES MANUFACTURING EFFICIENCY

Newburyport, Massachusetts – Pinpoint Laser Systems is introducing a new 2-Axis Micrograge Alignment Kit for use in checking manufacturing lines and related alignment applications. This new 2-Axis Laser Microgage can be used on roll and web lines, CNC cutting and milling tools, lathes, stamping presses, injection molding machines, extrusion systems, and other equipment. The 2-Axis Microgage will operate over a distance of 60 feet and is quickly adaptable to many industrial applications. **For additional information on the Dual Axis Microgage, contact Pinpoint Laser Systems at 1-800-757-5383, or www.pinlaser.com**

Have questions about federal government programs, benefits and services? Get the answers you can trust from the Federal Consumer Information Center. You have written our Pueblo, Colorado address for years. Now you can call us toll-free. We will answer your questions directly or get you to the person who can. Now the only question left is how to reach us. Simple.

JUST CALL TOLL-FREE: **1-800-FED-INFO**
Monday through Friday 8 a.m. to 8 p.m. Eastern Time
OR VISIT: **www.pueblo.gsa.gov/call**

A public service of this publication and the U.S. General Services Administration's Federal Consumer Information Center.

MICHELMAN

MICHELMAN, INC. ANNOUNCES THE INTRODUCTION OF RUSTBAN™ 105, A VCI (VAPOR CORROSION INHIBITOR) TREATMENT FOR PRIMARY PACKAGING OF FERROUS PARTS.

Cincinnati, Ohio – With RustBan treatment, metal products can be quickly and easily placed into the primary package for storage and shipment. RustBan treated packaging is ideal for the shipment of automotive parts, electronic components, gearing, machine tool components and tooling; or for the shipment of corrodible metal parts of any kind.

For more information about RustBan or other Michelman products, please contact Michelman, Inc., Phone: 1-800-333-1723. Fax: 513-793-2504. www.michem.com.

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Hoffman Estates, Illinois – A new, innovative unit designed to erase the durability, safety and light power problems associated with light sources comes to the marketplace. Suited for use in the harshest environments, from industrial shops and construction sites and cement production facilities, the Wobble Light simplifies the lighting issues, the fixture is encased in a polycarbonate dome that protects the bulb and socket against direct contact with debris and hard objects, while a shock absorption system takes the impact of any blow. Due to Wobble Light's polycarbonate dome, users no longer risk severe burns, or shattering the bulbs that can result in fire and abrasions. The unit's ability to disperse light in all directions (360°) makes it easy to illuminate large areas. **For more information, contact Wobble Light at (847) 230-3640 or visit www.wobblelight.com**

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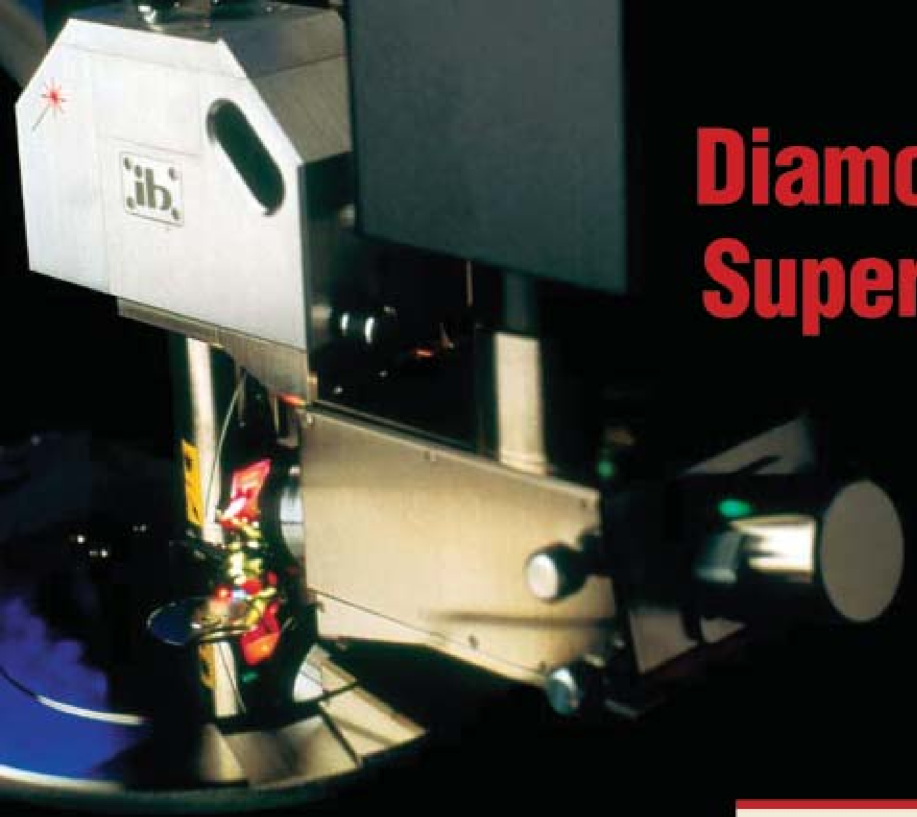


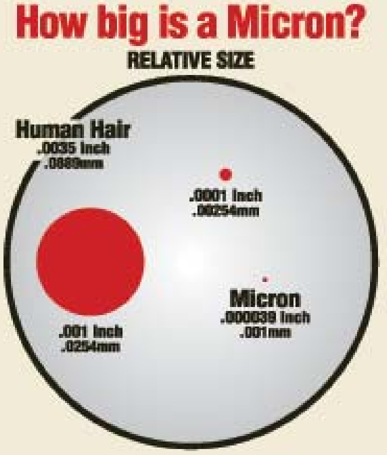
Diamond Polishing of Super-hard Materials for Electronic Components

BILL MANCINI – Microdiamant AG
Switzerland

Pushing The Limits With Polycrystalline Micron Diamond Powder

As we push the limits in all areas of manufacturing super-hard materials, diamond powders are becoming more and more of a factor. Very smooth finishes with no subsurface damage on extremely hard materials like sapphire and silicon carbide are required to produce some of the exotic electronic components needed in today's hi-tech markets. There is a vital importance of polycrystalline diamond powders in meeting these demanding requirements and polycrystalline diamond proves to be the abrasive of choice for these critical finishing applications.

Micron Diamond History



Let's first look at the background of diamond micron powders and describe the manufacturing process for polycrystalline diamond, which will help in understanding its unique properties. Diamond micron powders are less than 50 microns in size, about the size of a human hair. There are two basic types of diamond micron powders, monocrystalline and polycrystalline. Each type has its unique properties and advantages. Monocrystalline diamond can be found naturally and is also manufactured synthetically. Natural diamond is created underground at great pressure and temperature and is typically deposited in alluvial rock or in volcanic kimberlitic tubes.

The processing starts with crushing and sieving the ore. Then the diamond is separated from the rock by sedimentation typically yielding about 1 carat per ton of ore. About half of the diamond is gemstone quality and the other half is used for industrial applications.

Synthetic And Natural Monocrystalline Diamond

Synthetic monocrystalline diamond was invented in the early 50's and revolutionized the world of diamond abrasives. In this process large hydraulic presses provide pressures of

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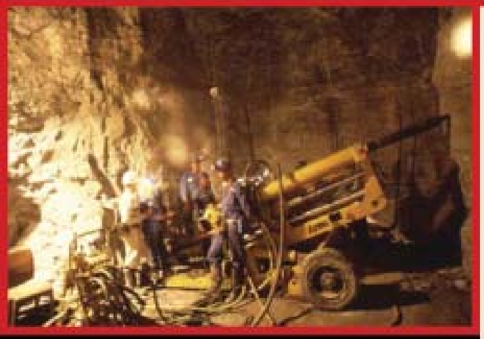


Photo 1 – Mining Diamond

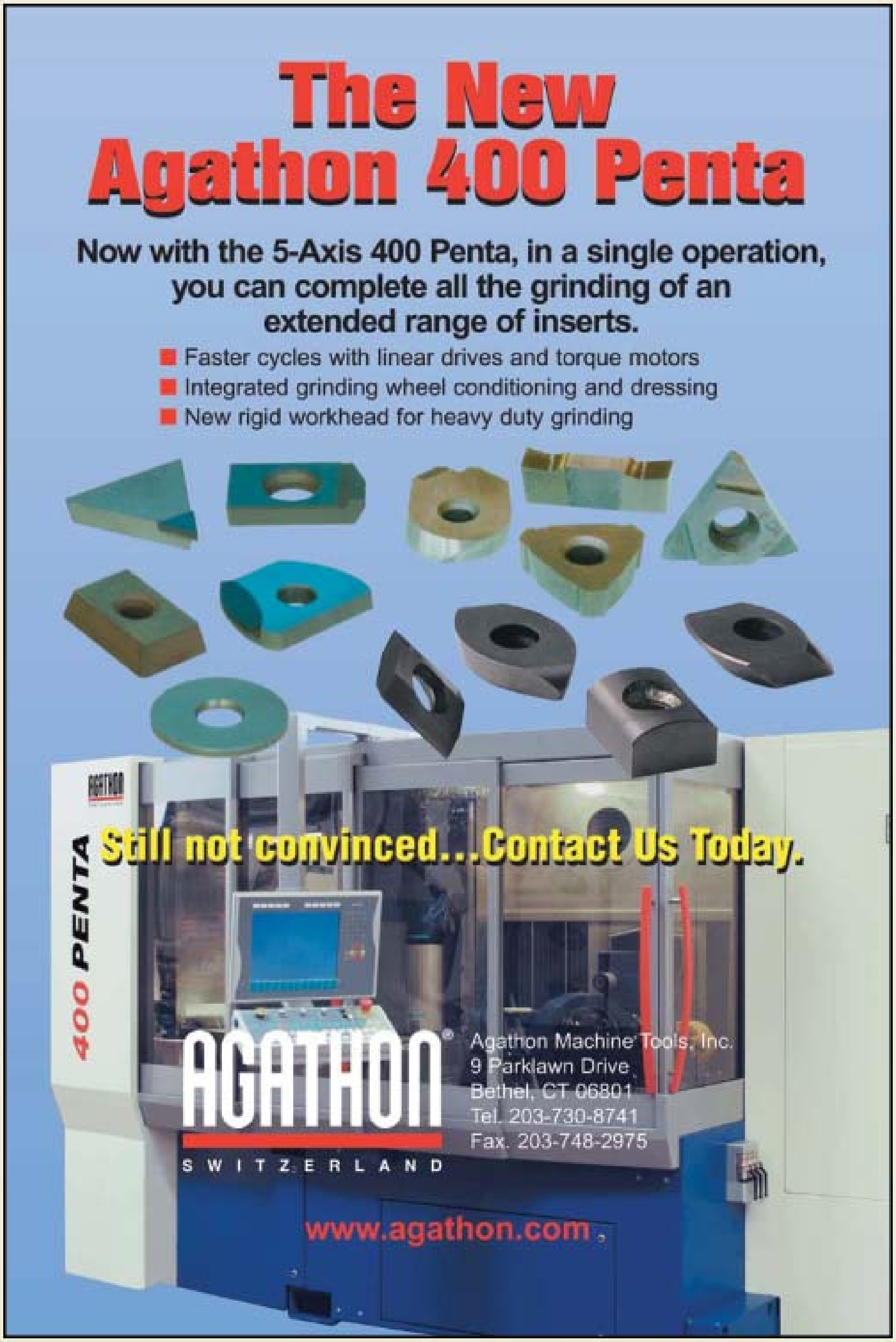
approximately 60,000 bars and temperatures of 1500 degrees Celsius to convert graphite powder into diamond. Adjusting the pressure-temperature profile and catalyst composition can modify the size and properties of the diamond. In most lapping and polishing operations, there are only minor differences between synthetic and natural monocrystalline diamond. The structure of this diamond features major cleavage planes (***Figure 1** & **Photo 3***) oriented parallel to the optical axis.

The strength of the diamond particle depends on the direction of the load. A particle breaks relatively easily in the direction parallel to the cleavage plane. A higher pressure is required to break it perpendicular to the planes. Synthetic monocrystalline diamond is gray to yellowish or greenish in color while natural is white to beige in color. It is used primarily for cutting and grinding tools for working stone, wood, metal and glass. These applications require large quantities of grit and mesh size diamond. Sizes below 50 micron (400 mesh) are a bi-product of the diamond synthesis and provide the raw material for making micron diamond sizes. This micron diamond powder is used as loose abrasives for polishing and lapping and fixed abrasives in grinding wheels. In these bonded tools, particle fracturing acts as a self-sharpening mechanism.

Manufacturing Polycrystalline Diamond

The process for manufacturing polycrystalline diamond was invented by E. I. DuPont de Nemours back in the late 60's. It was discovered by DuPont during massive R&D effort to find more uses for commercial explosives. Synthetic polycrystalline was made commercially available in the 1970s and is now made by at least six manufacturers worldwide. It is also important to understand that the small, niche market for polycrystalline diamond is about 10-12 million carats per year. The original DuPontexplosion compaction process generates pressures in excess of 500,000 bar and temperatures of about 1200 degrees Celsius. It begins by placing copper/graphite pellets into a large steel tube 6 inches in diameter and approximately 14 feet long (***Figure 2***).

Photo 2 – Natural Diamond



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To have your event or conference listed, please send information to:

Finer Points Event Calendar
P.O. Box 29460, Columbus OH 43229
Fax 614-797-2264 or
email: tkane-ida@insight.rr.com

December 15-16, 2004
Symposium Commemoration 50th Anniversary of Diamond Synthesis
Novatek, Provo, Utah
H. Tracy Hall Foundation
lmerrill@novatekonline.com

February 14-19
CSDA Annual Convention
The Fairmont
San Francisco, CA
Tel: 727-577-5004 or www.csda.org

February 18
CSDA Tech Fair
The Fairmont
San Francisco, CA
Tel: 727-577-5004 or www.csda.org

February 22-24

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March 1-3, 2005

SME Society of Manufacturing Engineers

HOUSTEX@ APEX
(Advanced Productivity Exposition)
George R Brown Convention Center
Houston, Texas
www.sme.org/houstex

March 3-4
Cutting Edge
St. Petersburg College
Clearwater, FL
Tel: 727-577-5004 or www.csda.org

March 5
OSHA Construction Safety
St. Petersburg College, Clearwater, FL
Tel: 727-577-5004 or www.csda.org

March 7-10
The 15th National Manufacturing Week
McCormick Place, Chicago, Illinois
Contact: Pete Zezima at (203) 840- 5447
or www.manufacturingweek.com

March 7-10
The International Laser Safety Conference
Marina Del Rey Marriott
Marina Del Rey, California
407-380-5588 or www.laserinstitute.org

March 7-12
Operator Certification
St. Petersburg College
Clearwater, FL
Tel: 727-577-5004 or www.csda.org

March 9-12
MTA Vietnam 2005
Showcases the Newest Machines and Tools in the Metalworking Industry
Ho Chi Minh International Exhibition and Convention Center
Ho Chi Minh City, Vietnam
Contact: MTA-MetalAsia exhibitions at 44 207 862 2087 or visit
www.mtavietnam.com

March 15-20

Taipei International Machine Tool Show

Taipei World Trade Center Exhibition
Halls Taipei, Taiwan
www.taipeitradeshows.com.tw/timtos

NATIONAL DRILLING ASSOCIATION
DCDMA

March 17-18
National Drilling Association (NDA) Annual Meeting
Las Vegas, NV
Contact NDA at
727-577-5006

April 4-7, 2005

SME Society of Manufacturing Engineers

WESTEC @ APEX
Los Angeles Convention Center
Los Angeles, California

April 18-20, 2005
Automation & Assembly Summit
Sheraton West Port Hotel –
Lakeside Chalet
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www.sme.org/automationassemblysummit

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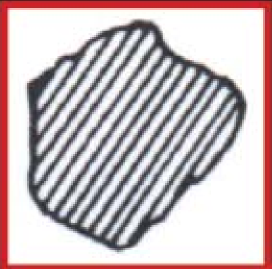

Figure 1 – Monocrystalline Diamond

Photo 3 – Monocrystalline Diamond

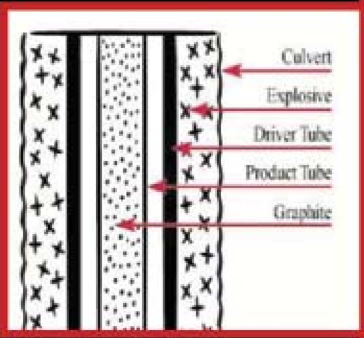

Figure 2 – Assembly Prior To Explosion

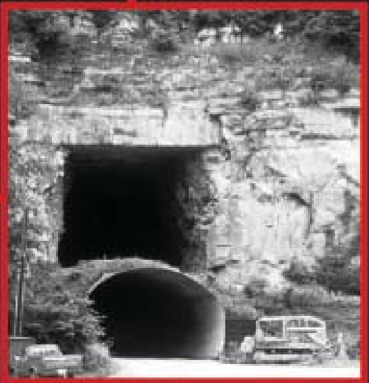

Photo 4 – Mine Entrance

Photo 5 – Assembly Prior to Shocking

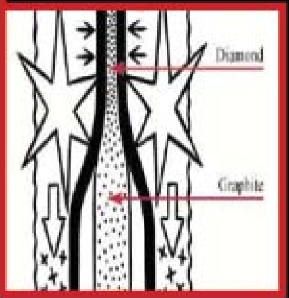

Figure 3 – Explosion Top To Bottom

This tube is placed into a larger, driver tube and steel plates are welded onto each end. A vacuum is drawn on the space between the tubes and this assembly is now ready for shocking.

The shocking or explosion compaction is done in a large underground limestone mine (***Photos 4 & 5***). The assembly is placed vertically and then a 42 inch steel culvert is placed over it.

A granular explosive is poured in the culvert and around the assembly. It is detonated at the top. As the explosion progresses down the assembly, it collapses the larger, driver tube onto the smaller, product tube (***Figure 3***). Pressures approaching 10 million psi are produced in the product tube. This high pressure is what transforms the hexagonal structure of graphite into the cubic structure of diamond. The diamond particles are produced ranging in size up to 50 microns.

Because the high pressure is a fast moving shock wave the individual diamond crystals do not have much time to grow. The resultant diamond particles are made up of thousands of tiny microcrystallites ranging in size from 1 to 20 nanometers (.001 to .02 microns). Although simple in theory, the explosion synthesis is very complicated in practice. The explosive pressure pulse must be sufficiently long to allow the microcrystallites to bond together to form the larger diamond particles. At the same time the heat generated must be controlled to prevent re-conversion of the diamond back to graphite. Using copper as a heat sink does this. Time, temperature, pressure and composition of ingredients must be controlled precisely in order to produce high quality polycrystalline diamond. After the explosive shocking, the diamond is degraphitized, cleaned, milled and graded into various sizes. Polycrystalline diamond powder is dark gray to black in color compared to the brighter monocrystalline diamond powder. The primary differences between polycrystalline and monocrystalline diamond are a result of the structure of the diamond particle. If we look at a photomicrograph (***Photo 6***) and drawing of cleavage planes (***Figure 4***) we can see some apparent differences.

Polycrystalline Diamond Properties

HIGHER TOUGHNESS

Poly diamond particles can withstand higher stresses. The poly diamond particles have cleavage planes that are interrupted every 10-200 angstroms. When high stress produces micro fractures, they are limited to small groups of crystallites on the perimeter (***Figures 5 & 6***).

Major cleavage cannot occur. This permits the use of higher unit pressures for lapping and polishing, often reducing the number of steps required and resulting in higher productivity. The mono diamond, however, fractures easily in the direction of the cleavage planes.

SELF-SHARPENING CHARACTERISTICS

High surface area and the inherent cleavage/wear process make poly diamond selfsharpening. As tiny microcrystallites

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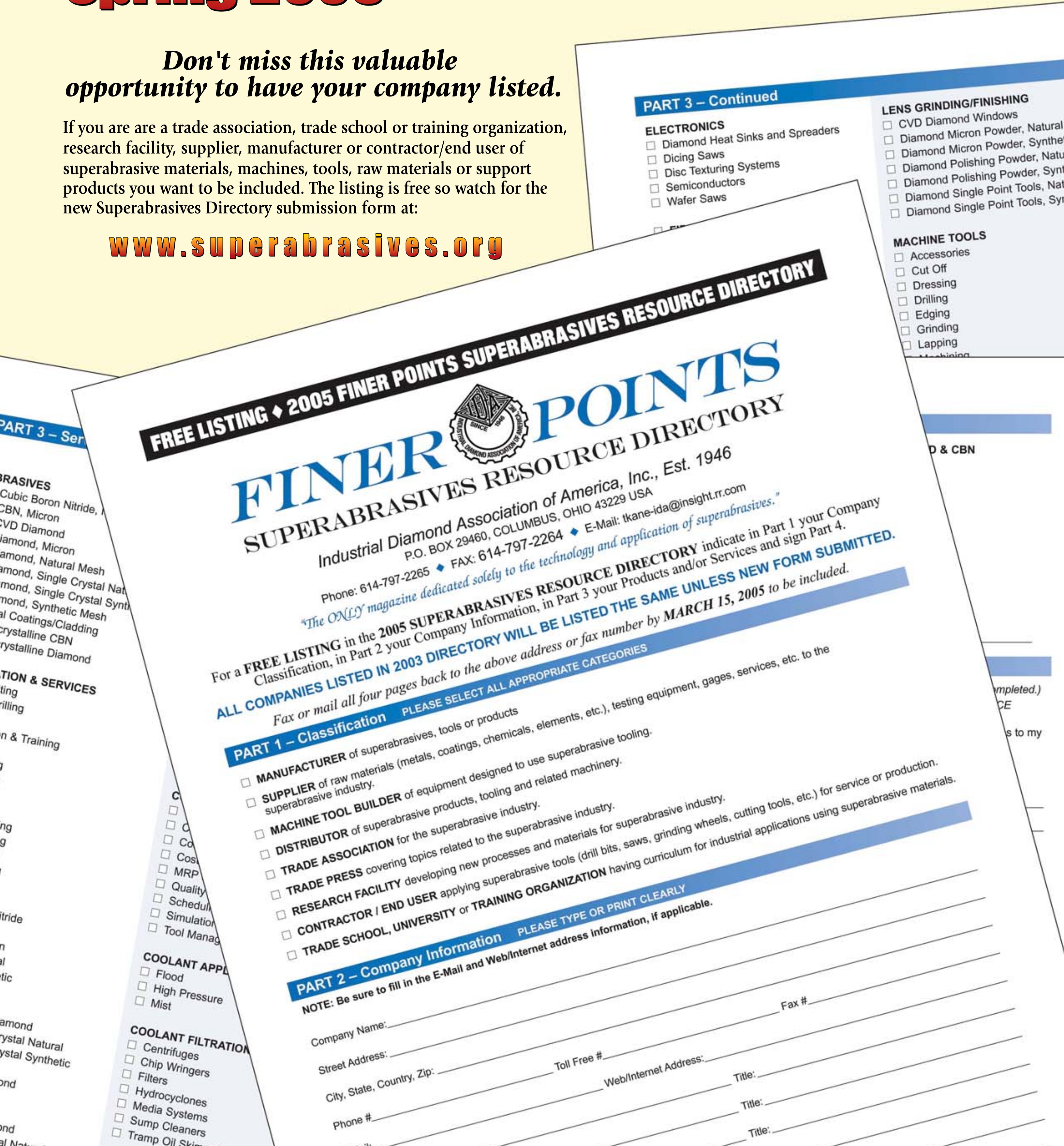

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break off they reveal more, equally rough and sharp crystallites with equally effective cutting edges. The blocky shape is preserved.

ULTRA-ROUGH SURFACE, FAST CUTTING PERFORMANCE

Poly diamond particles have 3 times the surface area of mono diamond making the particles extra-rough. This means many more cutting points, regardless of the orientation of the work-piece.

BLOCKY SHAPES FOR HIGHER DEGREE OF UNIFORMITY

The microstructure of poly diamond (*Photo 7*) lends itself to the creation of blocky particle shapes. This results in a higher degree of uniformity that makes it possible to micronize the powder into very narrow particle-size distributions (*Figure 7*). These narrow distributions reduce the number of particles that are too small to be effective or too large and overly aggressive.

When diamond is purchased with a broad distribution, you are paying for these particles that do not produce the desired results.

REDUCTION IN SUBSURFACE DAMAGE

Poly diamond particles are non-directional. Mono diamond particles have gross differences in abrasion resistance directionality due to the cleavage planes (*Figure 8*).

Because there are no cleavage planes in the poly diamond, the particles abrade the work surface uniformly, regardless of orientation. With poly diamond the micro cracking or spallation mechanism is lateral, in other words at right angles to the polishing pressure and parallel to the surface of the work-piece. This not only enhances material removal, but also minimizes remnant micro cracking and the need for subsequent polishing steps. By contrast, sharp, pointed particles inherent in mono diamond tend to produce deeper vertical micro cracking which must be either tolerated or removed by tedious and costly extra polishing steps (*Figure 9*) . Poly diamond does not produce any of the deep random scratches and micro cracking often caused by the directional mono particle.

In addition to the productivity benefits, the reduction in subsurface damage is particularly important for applications in which magnetic flux, thermal conductivity, and light transparency are significant criteria.

MINIMAL DUBBING

The polishing mechanisms of poly diamond produce less selective abrasion (dubbing) on corners and soft laminates and leaves smaller radii on slots and edges. In addition, poly diamond is gentle with materials that contain a variety of soft/hard/brittle domains such as complex cermets,

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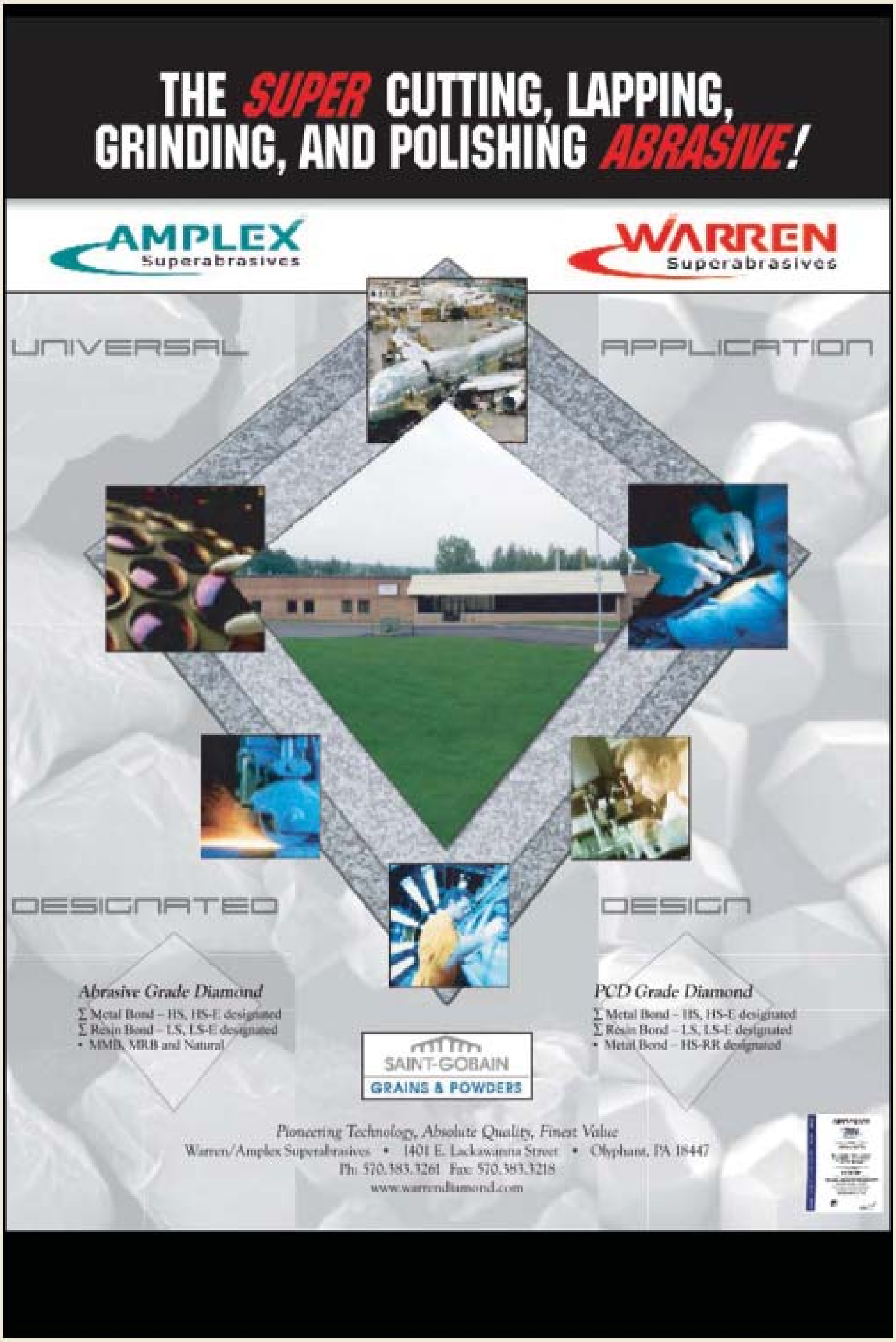

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ceramics, and metallographic or petrographic specimens. Typical applications for poly diamond in the electronics industry include texturing hard disk media and polishing of silicon carbide and sapphire wafers for LEDs and laser diodes.

Applications For Poly Diamond In The Electronics Industry

SAPPHIRE WAFERS

Sapphire wafers are used as substrates for the production of blue and white light emitting diodes (LEDs) and laser diodes. White LEDs (***Photo 8***) will eventually replace conventional light bulbs for lighting due to their extremely low energy consumption, high brightness and expected long service life.

White LED flashlights have already appeared on the market; other items will pop up soon. The mass production of laser diodes is used for CD and DVD players as well as the optical drives that are a standard in every new PC today. Other applications for sapphire include the production of chucks for silicon wafer production, lenses for TV and multimedia projectors, scratch-proof watch glasses, watch stones, industrial bearings, windows, surgery knifes, water jet nozzles etc.

SIC WAFERS

Silicon carbide (SiC) is a semiconductor material used for high-power and high frequency electronics (***Photo 9***). The main advantage of SiC components over the commonly used Si components is its thermal stability, which allows switching higher powers.

Using SiC instead of Si semiconductors for power transmission reduces energy losses drastically. It is believed that the efficiency of power generation and distribution can be increased from 80% to 95% by using SiC semiconductors for all electronic switches and filters.

WAFER PRODUCTION PROCESS – TABLE 1

TABLE 1: Typical Specifications for Sapphire Wafers for LED Production

Material	Monocrystalline High Purity Sapphire (Al_2O_3)	
Diameter	2 inch, 50.8mm	4 inch, 101.6mm
Thickness	330 +/- 25 µm	625 +/- 25 µm
Total Thickness Variation	< 20 µm	< 30 µm
TTV	< 20 µm	< 30 µm
Bow	Ra < 0.5 nm	Ra < 1 nm
Front Surface – Polished	Ra < 1 µm	Ra < 1 µm
Back Surface – Lapped		

Both sapphire and silicon carbide have similar mechanical properties. Both materials are extremely hard, with a Mohs hardness of 9. The only abrasive for efficient machining of these superhard materials is diamond (Mohs hardness 10). Let's take a brief look at the production process for superhard

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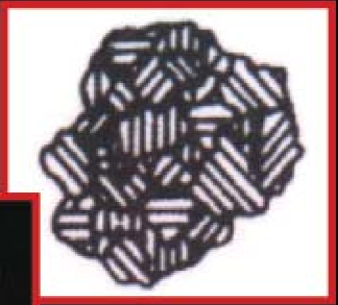
Figure 4 – Polycrystalline Diamond



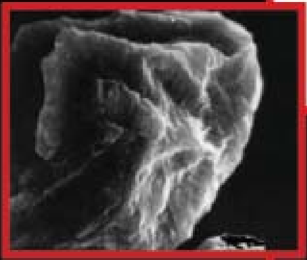
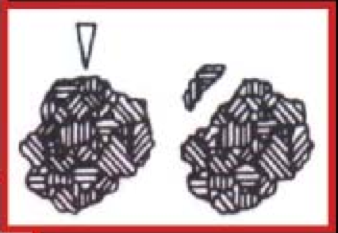


Photo 6 – Polycrystalline Diamond

Figure 5 – Cleavage Mode Self-sharpening Polycrystalline Crystal



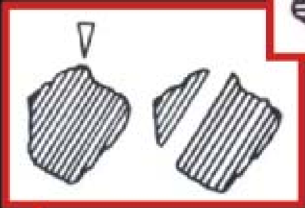


Figure 6 – Cleavage of Monocrystalline Diamond

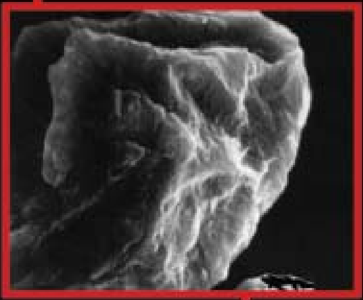
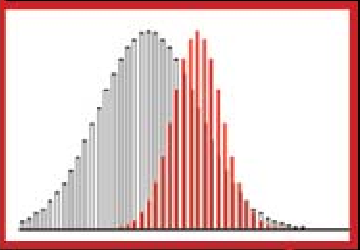


Photo 7 – Rough surface 3 times more area & more cutting points

Figure 7 – Narrow Particle Distribution



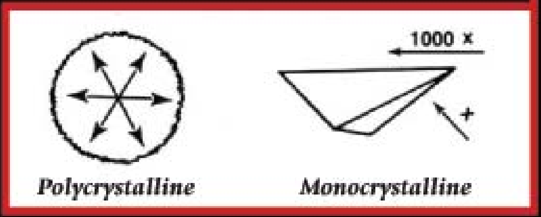


Figure 8 – Directionality of Crystal Types

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wafers, based on the example of sapphire wafers for LEDs. First here are the typical specifications for 2 inch and 4 inch wafers.

1. *Growing ingot (boule)*

Sapphire, also known as corundum or aluminum oxide (Al_2O_3) is obtained by various crystal growth processes (Verneuil, Czochralski or Kyropulos process). The appropriate process depends on the required quality and diameter of the ingot. Prior to slicing the ingot, the crystal axes have to be determined by X-ray.

2. *Slicing*

The crystal ingot is sliced to thin wafers by using a multi wire saw. Slurry containing monocrystalline diamond particles rides on a narrowly spaced web of hundreds of steel wires, which slices the ingot to wafers. Depending on the crystal quality and diameter, the cutting process takes up to 24 hours. The diamond sizes used for the sawing slurry typically range from 5 to 20 microns, and the slurry is recirculated for multiple uses.

3. *Grinding*

Depending on the surface quality of the sawed wafer, grinding of the wafers may be necessary. Grinding is performed on both sides using diamond grinding wheels.

4. *Diamond lapping*

Lapping and polishing are very critical operations with a direct influence on the yield of the finished products, which depends mainly on the surface quality of the polished wafer. For this reason, it is essential to use a diamond abrasive with a controlled and consistent diamond particle size and shape. One oversize or elongated diamond particle is enough to scratch the surface and to cause micro-cracks reaching far below the polished surface. Such defects will ultimately lower the yield of electronic devices.

Besides thinning the wafers to their final thickness, lapping is needed to remove several hundred microns of damaged material (*Photo 10*).

The damages include scratches, craters and micro-cracks below the surface, caused by the high local stress during the cutting and grinding operation. The low stress loads that are typical to lapping and polishing make it possible to a produce defect-free structure on and below the wafer surface. In most cases, the wafers are lapped on both sides on a lapping machine that is equipped with a grooved cast iron/copper lap plate. Ceramic chucks hold 3, 5 or more wafers, depending on their size and on the machine size. The diamond slurry is a mixture of a 4-micron polycrystalline diamond powder mixed with a specially formulated oil- or glycol-based carrier liquid. An automatic diamond-spraying device is used to apply a small but reproducible amount of diamond slurry onto the plate in short intervals. After lapping, the parts are cleaned in ultrasonic cleaning lines.

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Taking advantage of the high particle strength of polycrystalline diamond can increase the output of the relatively slow lapping process (*Figure 10*). Polycrystalline diamond powder allows for three times higher lapping pressures (1…3 bar or 15…45 PSI) compared to monocrystalline diamond of the same size. This approximately doubles the lap rate and thus increases the production output significantly.

5. Diamond polishing

Following the lapping operation, a polishing step on the functional wafer side produces the mirror-like surface finish with a roughness of typically less than 1 nm (Ra). The polishing machine is set up similar to the lapping machine. Instead of a lap plate, a selfadhesive textile polishing pad is used to accommodate a scratch-free surface. The working pressure is reduced to about 0.1 bar (1.5 PSI). The polishing slurry contains a 1- micron polycrystalline diamond powder, which is dispersed in a low viscosity, watersoluble carrier liquid. A major reduction of scratches and subsurface-damages is obtained by using polycrystalline diamond during this final polishing step. The explosion synthesis and subsequent milling ensure that all particles are of a blocky and consistent shape with no elongated particles. Despite the low working pressures that are present during polishing, comparably high removal rates are achieved with polycrystalline diamond. This can be explained by the rough particle surface and high number of cutting edges that participate in the polishing process simultaneously.

6. Chemical polishing

Unlike diamond polishing, this final step uses chemical etchants and colloidal fine abrasives to buff the wafer surface. After chemical polishing, the wafers are ready for deposition of the gallium nitride layer and the functional LED or laser diode structures.

In order to accommodate for both increasing demand and reduced production cost, the yield of finished wafers has to be optimized. What is true for traditional sapphire lapping and polishing applications (sapphire watch glasses, bearings and the like) is confirmed with this relatively new application: polycrystalline diamond does not only work up to twice as fast as monocrystalline diamond, it also yields a better, scratch-free surface finish. As a result, polycrystalline diamond reduces overall process cost and helps to maximize the yield and value of finished products.

PRICING CONSIDERATIONS

Unlike mono diamond, poly diamond powder is not a by-product of another process and as a result has a higher cost of manufacturing. It typically sells for 3 to 5 times the price of an equivalently graded mono diamond powder. Average mono diamond powder prices have dropped significantly over the last 10 years. And although poly prices have also dropped, the ratio of poly to mono has gone up. This has shifted some traditional poly uses back to mono. However, new and emerging electronics applications with more demanding criteria have kept the poly market growing. The many benefits described earlier make it economical value for generating higher yields and lower overall costs. ■

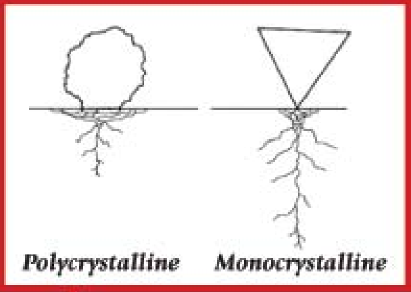

Figure 9 –
Surface Damage

Photo 8 –
White LED

Photo 9 –
SiC Wafer

Photo 10 –
Lapping Machine

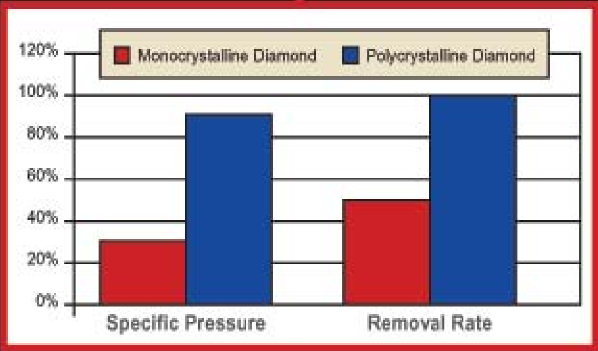

Figure 10 –
Lapping Results Polycrystalline Diamond Allows 3x Higher Lapping Pressures Removal Rate Doubled

Industrial Diamond Association of America, Inc.

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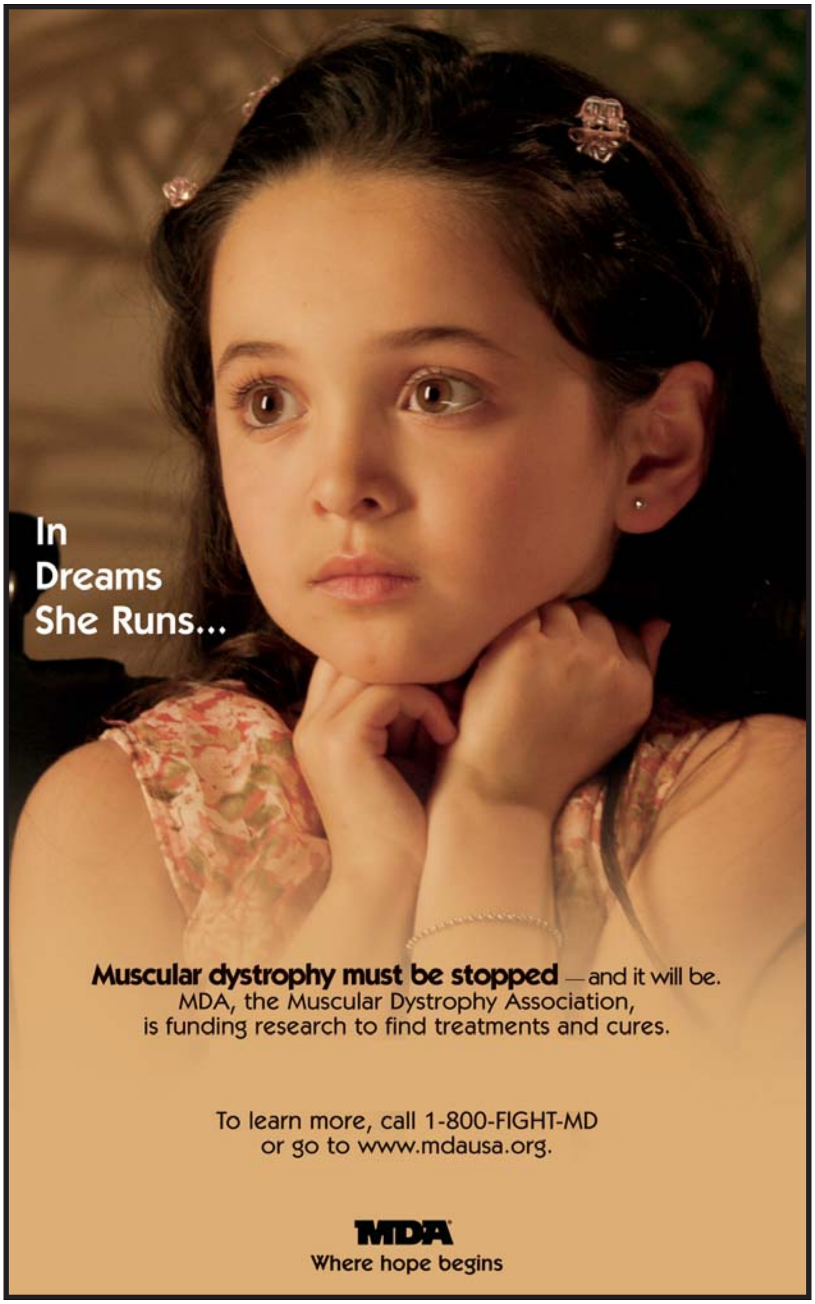
Available for any individual who has retired or is no longer active in the diamond or cbn business, but wishes to receive information mailings and attend IDA meetings as a member. Annual fee for Senior Member is **$50 per year**.



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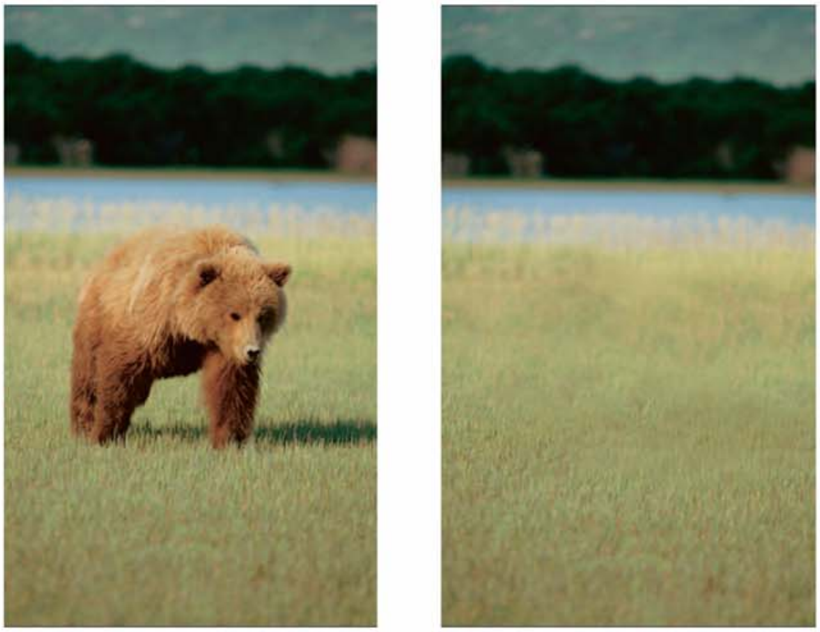

Here today…

But what about tomorrow? While hundreds of millions of Americans are enjoying the wonders of our national parks each year, the future of the very things they're coming to see is at risk.

For example, although the Mexican black bear population has been slowly recovering at Big Bend National Park, their ongoing survival is threatened.

Americans for National Parks is a coalition working to preserve these national treasures, and all the priceless experiences they provide. Find out how you can help at **www.americansfornationalparks.org.**

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CHECKLIST
of things to do…

FINER POINTS

☐ Renew my subscription to Finer Points magazine.

☐ Reserve my ad space in the next Finer Points issue.

☐ Submit article for consideration in future issue of Finer Points.

☐ Send Finer Points my business news, new products, new hires, promotions, industry news and other press release items.

☐ Pass this issue around to a friend.

☐ Send in my membership application to the IDA.

☐ Refer a company to IDA for consideration as a member.

☐ Visit the IDA Website at:
www.superabrasives.org
and submit a question or comment.

☐ Contact an IDA member for products or services.

☐ Plan to attend IDA Annual Meeting at Aladdin Resort & Casino April 20-22, 2005.

☐ Mark my calendar to attend Intertech 2006, April 24-26, 2006 in Atlanta.

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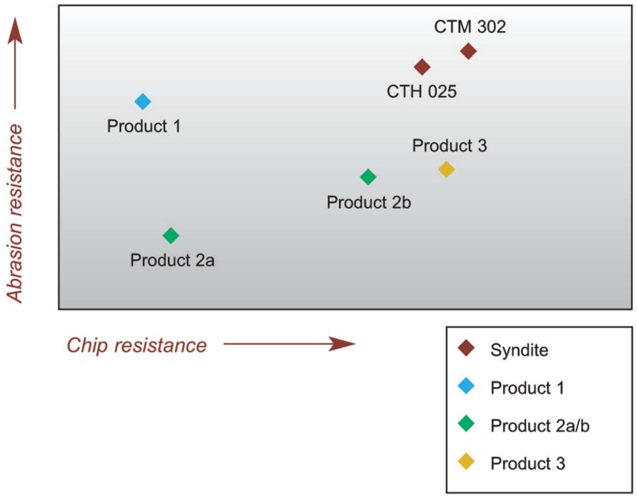

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